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~~APPARATUS FOR THE LOADING AND UNLOADING OF SUBSTRATES~~

The present invention relates to an apparatus for the loading and unloading of substrates and includes a conveying device for the linear transport of the substrates and at least one rotatable handling device for the transport of the substrates between the conveying device and at least one processing station.

Apparatus for the loading and unloading of substrates of the above type are known, for example, in arrangements for the processing of substrates, and in particular in arrangements for the lacquering or coating of substrates. In such arrangements substrates, for example CD/CD-R/DVD and other data storage means or data carriers, for the lacquering or the coating, are removed by a first handling device from a feed device and are deposited on a processing station, such as a lacquering station. After the processing, the substrate is again taken up by a second handling device and is deposited upon a device for transporting it away or is supplied to a further process.

US-A-4,824,309 discloses a vacuum processing unit having a vacuum pre-chamber, a buffer chamber and a processing chamber. The unit has a first wafer carrier in the buffer chamber, as well as a second wafer carrier, in order to transport wafers from the vacuum pre-chamber to the first wafer carrier in the buffer chamber. A third wafer

carrier is furthermore provided that transports the wafer from the first wafer carrier to the processing chamber, whereby the second and third wafer carriers are provided with conveyor belts.

The Speedline prospectus of the Leybold Systems Company, 2/97, pages 6 to 9, shows an integrated CD-manufacturing apparatus where different process units for the manufacturer of CD's are integrated into an arrangement. For the transport of elements that form the CD's, conveyor belts as well as mechanical grippers are utilized.

DE-C-197 22 408 shows an apparatus and a method for the separated transport of substrates upon two separated transport stretches, with two supply stations, at least two processing stations, and two delivery stations. A transport device for the transport of the substrates is rotatable about an axis of rotation by a first angle, and has at least two grippers that are disposed along a circular arc about the axis of rotation at a prescribed angular spacing. The angular spacing between the two supply stations, between the two processing stations and between the two delivery stations is respectively equal to the prescribed angular spacing, and the first angle is greater than the prescribed angle.

A further device for carrying out different processes from a work piece is known from DE-C-41 27 341. The work pieces are transported to and away from a rotary switching table via a linearly movable transport carriage having respectively three transport arms arranged on

both sides of the carriage. The rotary switching table leads the work pieces to various processing stations.

Further reference is made to US-A-5,700,127, which shows a substrate processing apparatus having various processing units. The substrates are supplied to and removed from the various processing units via a handling device. The handling device has a substrate gripper that is linearly movable in the x, y and z directions, and is rotatable about the z axis.

With such apparatus, for the loading and unloading of a processing station separate handling devices as well as separate feed and discharge devices are provided. This results in a greater requirement for space for the components of the apparatus, which in particular in clean room environments leads to high costs.

Proceeding form such apparatus, it is an object of the present invention to provide an economical apparatus having a low number of components and requiring less space.

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This object is inventively realized with an apparatus where the conveying device is disposed between two processing stations and the at least one handling device is disposed over the conveying device. The arrangement of the conveying device between at least two processing stations has the advantage that due to the rotatable handling device that is disposed over the conveying device, a plurality

of processing stations can be provisioned with a low requirement for space.

Pursuant to one preferred embodiment, the point of rotation of the handling device is disposed on a central axis of the conveying device. The handling device preferably has receiving devices disposed on a circumferential circle for the substrates, which are preferably uniformly spaced upon the circumferential circle. This results in a circular symmetry that by a rotational movement of the handling device enables the simple loading and unloading of a plurality of processing stations.

So that the processing stations are not covered during the processing of substrates, and to avoid media from being carried off, the receivers are preferably disposed on radial arms of the handling device in order to provide free spaces between them.

The linear conveying device is advantageously a conveyor belt that preferably extends between a loading station and an unloading station. This has the advantage that for the feeding and discharging of the substrates only a single conveyor belt is required, thereby reducing the number of components that are needed.

Pursuant to a particularly preferred embodiment, the conveyor belt is provided with carriers for a reliable holding and a defined positioning of the substrates. In this connection, it is advantageous that the carriers be uniformly spaced on the conveyor belt in the

direction of movement in order to simplify the control of the conveyor belt, whereby constant movement intervals can be provided. For the formation of a symmetry relative to the handling device, the carriers are disposed on the central axis of the conveyor belt, or at least two carriers are symmetrically disposed relative to the central axis of the conveyor belt, thereby simplifying the control of the handling device.

It is also advantageous if at least two carriers are disposed on the circumferential circle for the loading and unloading of the substrates in order to make possible the simultaneous receipt and/or deposit of a plurality of substrates.

Pursuant to one preferred embodiment, central receiving points of the processing stations are disposed on the circumferential circle, preferably being disposed in pairs diametrically across from one another on the circumferential circle.

In this connection, the processing stations are preferably of the same type within the pairs. This again increases the symmetry of the apparatus and thus simplifies the control of the handling device.

It is of particular advantage if processing stations that are disposed adjacent one another on the circumferential circle are provided with the same drive means, which reduces the number of drive means required and the cost connected therewith.

The number of receiving devices of the handling device advantageously corresponds to the number of carriers disposed upon

the circumferential circle and the processing stations. This enables an effective loading and unloading of all of the processing stations and carriers upon the circumferential circle in one operation. In this connection, during the loading and unloading, preferably all of the receivers are disposed either over the carriers upon the conveying device or over the receiving points of the processing stations.

Pursuant to one preferred embodiment, a control device is provided for the simultaneous opening and closing of the receiving devices of the handling device in order to simultaneously receive the substrates from the carriers and the processing stations or to be able to deposit them thereupon.

WS 947 The invention will be subsequently described in detail with the aid of preferred embodiments with reference to the figures. Shown are:

Figure 1 a plan view of an arrangement having an apparatus for the loading and unloading of substrates pursuant to a first embodiment of the invention;

Figure 2 a plan view of an arrangement having an apparatus for the loading and unloading of substrates pursuant to a second embodiment;

Figure 3 a plan view of an arrangement having an apparatus for the loading and unloading of substrates pursuant to a third embodiment.

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Figure 1 shows an arrangement 1 for the processing of CD's. The arrangement 1 comprises a first embodiment of an apparatus 2 for the loading and unloading of substrates pursuant to the present invention, and is provided with a linear conveying device 3 and two handling devices 4 and 5. The arrangement 1 is furthermore provided with eight processing stations 6A to D and 7A to D, upon which the CD's are processed. The arrangement 1 is disposed on a foundation or support means 8, which is, for example, a mineral ingot.

The handling device 4, the processing stations 6A to D and the linear conveying device 3 together form a first group of the arrangement 1. Further, the handling device 5, the processing stations 7A to D, together with the linear conveying device 3 form a second group of the arrangement 1 that corresponds to the first group. The first and the second group of the arrangement together utilize the single linear conveying device 3.

The linear conveying device 3 of the apparatus 2 of the first embodiment has a conveyor belt 13 that runs along a track or line 14. At the reversing ends 15 and 16 of the conveying device 3, the conveyor belt 13 is mounted on an idler roller 13 and a drive roller 18 respectively. Provided at the end 16 of the linear conveying device 3 is a drive means 19. The drive means 19 is a servomotor having a suitable, non-illustrated control device, and driving the drive roller 18 for the transport of the conveyor belt 13.

The linear conveying device 3 has a central axis 20, which at the same time is the central axis of the conveyor belt 13.

Carriers for CD's that are not shown are disposed on the conveyor belt 13. In Figure 1, eight carriers 21 to 28 are shown. The carriers 21 to 28 are disposed on the central axis 20 of the conveyor belt 13 at a uniform spacing d.

Disposed adjacent to the reversing ends 15 and 16 of the conveying device 3 are non-illustrated handling devices for the loading and unloading of the CD's. In Fig. 1, the CD's at the reversing end 15 are placed upon the conveyor belt 13 by a suitable, non-illustrated handling device, and at the reversing end 16, after the processing, the CD's are again removed by a further suitable, non-illustrated handling device.

The handling devices 4 and 5 are held from above over the conveyor belt 13 such that via suitable drive means they are not only rotatable but also adjustable in height. Since the handling devices 4 and 5 are essentially identical, in the following only the handling device 4 will be described.

The axis of rotation of the handling device 4 extends through the center point 40 of a circumferential circle 41. The axis of rotation of the handling device 4 is disposed vertically upon the central axis 20 of the linear conveying device 3. The handling device 4 is provided with six respective receiving devices or receivers 42 to 47, which are disposed

upon six radially extending arms 48 to 53. The receivers 42 to 47 are suitable, for example by opening and closing, to receive and again deposit CD's and for this purpose are suitably controlled by a non-illustrated control device.

As can be seen from Figure 1, the receivers 42 to 48 of the handling device 4 are disposed upon the circumferential circle 41 and are uniformly spaced upon the circumferential circle 41. The six receivers 42 to 47 are respectively provided at an angle of $\alpha=60°$ upon the circumferential circle 41.

The processing station 6A to 6D and 7A to 7D are associated with the two handling devices 4 and 5, as already indicated above. For this reason, in the following only the processing stations 6A to D are described, whereby a corresponding description is applicable for the processing stations 7A to D in conjunction with the handling device 5.

The processing stations 6A and 6C are lacquering or coating stations that have a rotary plate and pivotable coating nozzles. The processing stations are furthermore provided with central receiving points 60A and 60C for the CD's that are to be processed. The processing stations 6B and 6D are edge-cleaners having a rotary plate and an edge scraper for cleaning the edges of the CD's after the coating process. The processing stations 6B and 6D are similarly provided with receivers having central receiving points 60B and 60D for receiving the CD's at the processing stations.

The central receiving points 60A to 60D are disposed upon the circumferential circle 41, and are disposed in pairs on the circumferential circle 41 diametrically opposite one another. Thus the central receiving points 60A and 60C, and the central receiving points 60B and 60D, respectively form a pair.

The processing stations that are disposed diametrically opposite one another on the circumferential circle 41 are the same type. The processing stations 6A and 6C are respectively coating stations, and the processing stations 6B and 6D are respectively edge-cleaning stations.

The central receiving points 60A to 60D are arranged in such a way that central receiving points of processing stations that are directly adjacent one another on the circumferential circle are spaced by the angle $\alpha=60°$, and the central receiving points are respectively similarly spaced by an angle of $\alpha=60°$, relative to a point of intersection of the central axis 20 of the conveying device with the circumferential circle 41.

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The center points 40,65 of the circumferential circles 41, 66 of the first and second groups of the arrangement 1 are spaced upon the linear conveying device 3 by a distance equal to three times the spacing d between adjacent carriers. The diameters of the two circumferential circles 41 and 66 are the same, and correspond to two

times the spacing d between adjacent carriers upon the conveyor belt 3.

The arrangement 1 is shown with a specific number of processing stations, although this number is only exemplary and can be varied. In addition, the processing stations need not be coating and edge-cleaning stations, but rather other processes can also be carried out. It is also not necessary that different processes be provided. Furthermore, instead of CD's, other substrates could also be processed.

Figure 2 shows a second embodiment of the arrangement 1b having a further, third handling device, which is the same as the handling devices 4 and 5 of the first embodiment of Fig. 1. The third handling device is similarly disposed over the conveying device 3b, which is longer than the linear conveying device 3 of the first embodiment. The axis of rotation of the third handling device is disposed vertically upon the central axis 20b of the conveying device 3b. The third handling device, together with further four processing stations, forms a third group of the arrangement 1b, whereby the four processing stations are again two coating stations and two edge-cleaning stations.

The central receiving points of CD receivers of the processing stations, as well as the receivers of the handling devices of the respective groups, are disposed upon respective circumferential

circles, the center points of which are disposed upon the central axis 20b of the conveying device 3b and coincide with the axis of rotation of the handling devices, as can be seen from Figure 2.

The diameters of the respective circumferential circles are the same. In the embodiment of Figure 2, the diameters of the circumferential circles correspond to three times the spacing d between adjacent carriers 21b to 36b of the conveying device 3b. The center points of adjacent circumferential circles are disposed upon the central axis 20b of the conveying device 3b at a spacing that corresponds to four times the spacing d between two adjacent carriers of the conveying device 3b.

As will be described subsequently in detail in conjunction with the preferred manner of operation of the arrangement 1 or 1b, the first embodiment and the second embodiment also differ with regard to the loading of the carriers of the conveying device 3 or 3b with CD's.

Figure 3 shows an arrangement 1a that has a third embodiment of an apparatus 2a pursuant to the present invention. The apparatus 2a has a linear conveying device 3a and a rotatable handling device 4a. The arrangement 1a furthermore has processing stations 80A to H.

Sub Q7 The linear conveying device 4a has a track or line 14a upon which is disposed a conveyor belt 13a. As described above for the conveyor belt 13 of the first embodiment, the conveyor belt 13a also

extends between two reversing ends 15a and 16a of the linear conveying device 3a, and is driven by means of a drive roller 18a at the reversing end 16a by a suitable drive means 19a, such as a controlled servomotor.

The conveying device 3a has a central axis 20a that is also the central axis of the conveyor belt 13a. Carriers for CD's are disposed upon the conveyor belt 13a. In Figure 3, carriers 21a to 28a are visible. The carriers are disposed in pairs symmetrically relative to the central axis. For example, the carriers 21a and 28a, or the carriers 22a and 27a, form a symmetrical pair relative to the central axis 20a.

The handling device 4a is held from above over the conveyor belt 13a and is disposed such that, via a suitable drive means, it is not only rotatable but also adjustable in height. The axis of rotation of the handling device 4a is disposed perpendicular upon the central axis 20a of the linear conveying device 3a. The handling device 4a has twelve receivers 400a to 411a on corresponding radially extending arms 420a to 431a. The receivers 400a to 411a serve for receiving and depositing CD's, and for this purpose are suitably controlled by a non-illustrated control device.

As shown in Figure 3, the receivers 400a to 411a are disposed on a circumferential circle 41a, whereby the axis of rotation of the rotatable handling device 4a extends through the center point 40a of the circumferential circle 41a. The receivers 400a to 411a are

uniformly spaced from one another upon the circumferential circle at an angle $\alpha=30°$.

The diameter of the circumferential circle 41a is such that in the position of the apparatus 2a shown in Figure 3, a total of two pairs of carriers, which are symmetrical relative to the central axis 20a, are disposed on the conveyor belt 13a on the circumferential circle 41a. In tangible terms, in Figure 3, this is the pair of carriers 23a, 26a and 22a, 27a. Accordingly, the diameter of the circumferential circle 41a corresponds to the spacing between the carriers 22a and 26a or between the carriers 23a and 27a.

The processing stations 80A to 80H shown in Fig. 3 are either coating stations 80A to 80D for coating CD's or edge-cleaning stations 80E to 80H. The coating stations 80A to 80D have rotary plates, pivotable coating nozzles, and receivers having respective central receiving points 81A to 81H for the CD's that are to be processed. The edge-cleaning stations 80E to 80H have rotary plates, edge scraper, and receivers having central receiving points 81E to 81H.

Respective central receiving points 81A to 81H of the processing stations 80A to 80H are disposed upon the circumferential circle 41a, and are disposed in pairs diametrically across from one another on the circumferential circle 41a. In this connection, the processing stations within these pairs are of the same type.

Furthermore, respectively two of the same type of processing stations are disposed adjacent to one another upon the circumferential circle 41A and are driven by a common drive means, although separate drive means could also be provided.

The manner of operation of the apparatus 2 pursuant to the first embodiment is briefly described in the following.

Disposed on the processing stations are already treated CD's, which were coated in the coating stations 6A, 6C and their edges were cleaned in the edge-cleaning stations.

During the treatment or processing of the CD's, the receivers 42 to 47 on the radial arms of the handling devices 4 are disposed in an intermediate position, i.e. they are disposed between adjacent processing stations. Thus, the handling devices 4 and 5 are positioned in such a way that none of the receivers 42 to 47 are disposed over the processing stations. With reference to Figure 1, this means that the handling devices 4 and 5 are rotated out of their illustrated position by $\alpha/2=30°$.

At the reversing end 15, the carriers of the conveyor belt are provided by the loading station with CD's that are to be processed. After the loading or provision process, only those carriers of the conveyor belt 13 are to be loaded that are positioned upon the circumferential circles 41 and 66. With the arrangement 1 of Fig. 1, this is effected in such a way that initially a carrier at the reversing end

15 is provided by means of the loading station, the next one is not provided, the two following carriers are again provided, again a carrier is not provided, and finally one more carrier is provided with a CD that is to be processed. For this purpose, the conveyor belt is always cycled further by a distance d until finally all carriers that are provided with a CD are disposed upon one of the circumferential circles 41 or 66. In Figure 1, these are the carriers 22, 24, 25 and 27.

During the loading of the carriers, already processed CD's are removed from the conveyor belt from a preceding operating cycle at the reversing end 16 by the unloading station.

Sub Q8 As soon as the loaded carriers 22,24,25 and 27 are disposed upon the circumferential circles 41 or 46, the handling devices 4 and 5 are rotated into the position shown in Figure 1, in which the receivers 42 to 47 are disposed either over the central receiving points 60A to 60C or over the carriers 22 and 24. The same applies for the second group of the arrangement 1, which comprises the handling device 5, the four processing stations 7A to 7C, and the conveyor belt 13.

In this position, the receivers 42 to 47 are lowered for engaging the CD's and are subsequently again raised. In this connection, the unprocessed CD's and the processed CD's are simultaneously taken up and raised together from the carriers and from the receivers of the processing stations respectively.

With the taken-up CD's, the handling device 4 is rotated in a clockwise direction by an angle $\alpha=60°$. In this connection, for example, the unprocessed CD taken up by the carrier 22 is transported to the central receiving point 60A of the processing station 6A, and the CD taken up by the coating station 6A is transported to the edge-cleaning station 6b, etc..

In the new position, the receivers are lowered and place these CD's either upon the central receiving points of the processing stations or upon the carriers of the conveyor belt 13.

After the CD's have been deposited upon the carriers and the processing stations, the handling device 4 is again rotated into an intermediate or park position in which the arms 48 to 53, and hence the receivers of the handling device, are disposed between adjacent processing stations. The same applies for the second handling device 5 and the receivers thereof.

During the processing of the CD's in the coating and edge-cleaning stations, the conveyor belt 13 is unloaded and is re-supplied or loaded with CD's that are to be processed, as described previously.

The arrangement 1b of Figure 2 differs from the arrangement 1 of Figure 1 essentially in that a third group, comprising a third handling device and four corresponding processing stations, is disposed along the lengthened conveying device 3b.

From this there results a difference during the operation of the loading and unloading apparatus of Fig. 2 relative to that of Fig. 1. The carriers of the conveyor belt are provisioned with CD's by the loading station at the reversing end 15b in such a way that between two carriers that are provided with CD's, and that are disposed upon a common circumferential circle of a respective group, two carriers remain free, which after the provision of the conveyor belt are disposed below the handling devices. Thus, after the first carrier is provided with a CD, two carriers are left free, then again two carriers are provisioned, and then again two carriers are left free, etc.. For the receipt and the deposition of the CD's by the receivers of the handling devices, the conveyor belt 13b is positioned into the position shown in Figure 2, whereby the loaded carriers are disposed upon the respective circumferential circles of the handling devices.

The three handling devices are then controlled for the transport of the CD's upon the processing station and upon the carriers, as was described in conjunction with the manner of operation of the arrangement of Fig. 1.

With the arrangement 1a of Figure 3, the concept of the invention is extended further in that for the one handling device 4a a total of twelve receivers 400a to 411a are provided. In the position shown in Figure 3, four unprocessed CD's can be simultaneously accommodated by the receivers from the carriers 22a, 27a, 23a and

26a and from the central receiving points 81A to 81H of the processing stations 80A to 80H. After the raising of the CD's, the handling device 4a is rotated by an angle $2\alpha=60°$, in other words twice the angular spacing between two adjacent receivers upon the circumferential circle 41a. Thus, simultaneously a total of four CD's are supplied to the coating stations 80A to 80D, four CD's are supplied to the edge-cleaning stations 80E to 80H, and four processed CD's are supplied to the carriers 22a, 27a, 23a, and 26a. After the deposit of the CD's, the handling device 4a is rotated into an intermediate position, as with the preceding embodiments, in which the receivers are disposed between the processing stations or the carriers, or a processing station and a carrier. The processed CD's can thereupon be transported to the unloading station, the carriers can be supplied via the loading station with new CD's that are to be processed, and the CD's can be processed upon the processing stations.

The invention was described with the aid of preferred embodiments of the invention without thereby being limited to the special embodiments.

For example, the arrangements of Fig. 1 and Fig. 2 can be expanded by further groups that comprise a handling device similar to the handling devices 4 and 5 and having a suitable number of processing stations, and in particular accompanied by appropriate extension of the linear conveying device 3. In this connection, care

must be taken that the diameters of the respective circumferential circles have a suitable ratio to the spacings d of adjacent carriers upon the conveyor belt 13,13a or 13b, and that only those carriers be loaded with CD's that are then disposed upon the corresponding circumferential circles. Furthermore, instead of CD's also other substrates can be processed, or the linear conveying device could also be realized in a manner different than by the conveyor belt 13, 13a or 13b.

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